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AN OPERATIONAL TEST OF A NATURAL-SHAPED LOGGING BALLOON

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Figure 1.--Raven Industries, Inc., natural-shaped balloon.

ABSTRACT

A three-month test was performed to evaluate a natural-shaped balloon under logging conditions, near Reedsport, Oregon. Data were collected on the balloon's availability, maintenance records, handling requirements, and yarding performance. The balloon was found to be stable and operable in winds up to 25 m.p.h. and capable of surviving storms when properly bedded down.

INTRODUCTION

One of the major concerns in balloon logging is the stability of the balloon. Exposed as it is to a variety of weather conditions--particularly to frequently varying winds in mountainous regions--a balloon must remain relatively stable in flight. To determine the flight characteristics of a "natural-shaped" balloon when used in logging, Raven Industries, Inc., Sioux Falls, S.D., and Bohemia Lumber Co., Culp Creek, Oreg., ran tests during the summer and early fall of 1967 on the Siuslaw National Forest near the central Oregon coast.

The natural-shaped balloon (fig. 1) has several characteristics that distinguish it from other types. Its name is derived from the fact that a lifting gas naturally assumes this shape under the weight of the fabric containing it. The fabric of the fully inflated balloon is stressed uniformly,[1] which allows use of a material of uniform thickness in construction. This minimizes the weight of material required to contain a given amount of gas, and by this means, the design achieves the highest static lift efficiency of any balloon shape.

The natural-shaped balloon achieves its high static efficiency and simplicity in design and construction at the expense of airfoil characteristics; thus, any relative air movement produces dynamic drag without dynamic lift.

Prior to the tests, there was no known documentation of experience on large natural-shaped balloons operating in a tethered mode. Common experience indicated that small tethered balloons have a tendency to oscillate excessively in wind. Military and industrial experience showed a high degree of stability for large natural-shaped free balloons in varying wind conditions because the relative wind is zero, but the effect of adding a tether cable could not be clearly predicted. Nor could data from wind tunnel tests be used to forecast success in logging, since the use of wind tunnel data in a stability analysis of tethered balloons is presently not a clearly defined science.

Because of the unique characteristics of the natural-shaped balloon, its performance in logging could only be evaluated by a field test. Consequently, the Pacific Northwest Forest and Range Experiment Station contracted with Raven Industries, Inc., to report on the results of the test. Under the terms of the contract, Raven Industries was to provide detailed test data covering 160 operating hours.

The test was completed in October 1967 under the direction of Terry Wright, project engineer with Raven Industries, and in cooperation with Bohemia Lumber Co.

The following information has been developed from data taken during this 160-hour test period.

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[1]Smalley, Justin H. Balloon design data in gore lengths. Air Force Cambridge Research Laboratories, AFCRL-65-447, 63 pp., illus. 1965.

DESCRIPTION OF TEST

Site Layout

The logging site was on the north shore of the Umpqua River, approximately 10 miles east of Reedsport, Oreg. The location was the U.S.D.A. Forest Service Brandy Bar sale, units 1 and 2 (fig. 2). The site included 92 acres of clearcutting plus 7 acres of road right-of-way outside the cutting units.

The elevation ranged from near sea level to over 800 feet. The slopes averaged 55-60 percent and were fairly constant.

Timber Types and Volumes

The sale contained 2,900,000 board feet of 80-year-old Douglas-fir with miscellaneous associated species. The stand averaged 21 inches at breast height; the stand had a cruise defect of 18 percent and averaged 29,300 board feet per acre.[2]

Log Transport System

Both units were logged downhill by balloon. Yarding distances varied from approximately 200 to 1,500 feet. From the landing, the logs were swung by tractor to the north shore of the Umpqua River. They were dumped into the river and rafted across to the Brandy Bar landing on the south shore of the Umpqua River, where they were loaded onto trucks and hauled to the mill.

Equipment Description

The following equipment was used in the yarding operation:

	Quantity
Natural-shaped balloon	1
Balloon transfer vehicle	1
Helium storage trailer	1
Yarder	1

[2]Brandy Bar Timber Sale Prospectus. August 1965. Siuslaw National Forest, Corvallis, Oreg.

The natural-shaped balloon had a diameter of 82 feet and held 250,000 cubic feet of helium. It weighed 3,000 pounds and had a net static lift of approximately 11,500 pounds. The fabric was of a dacron base with elastomer coating on both sides. The load was suspended from the envelope with a modified tangent harness system. A light fabric was attached to the suspension system, which formed an external skirt-ballonet. It was pressurized by ram air acting through one-way valves around the lower circumference of the skirt.

The rigging was similar to that in conventional high-lead yarding, except that the balloon was tethered 500 feet above the butt rigging to provide direct lift to the logs.

The tagline was put together in segments so that its length could be quickly changed to suit the requirements of individual turns, thus reducing block changes. The actual length varied from 150 feet up to 300 feet.

The balloon was moved from the bed-down area to the yarder by the balloon transfer vehicle--a double drum winch mounted on a modified M-4 tank chassis. The bottom of the tank hull was filled with scrap steel to provide additional weight.

A helium storage trailer was kept at the site to supply replacement gas to the balloon.

The yarder was a prototype interlocking unit, manufactured specially for balloon logging by Washington Iron Works, Seattle, Wash. It was mounted on an M-6 tank chassis for easy mobility and was powered by a 700-horsepower diesel engine driving through a 4-speed transmission. In fourth gear, the yarder was capable of a line speed of 2,200 feet per minute. However, for this operation, the

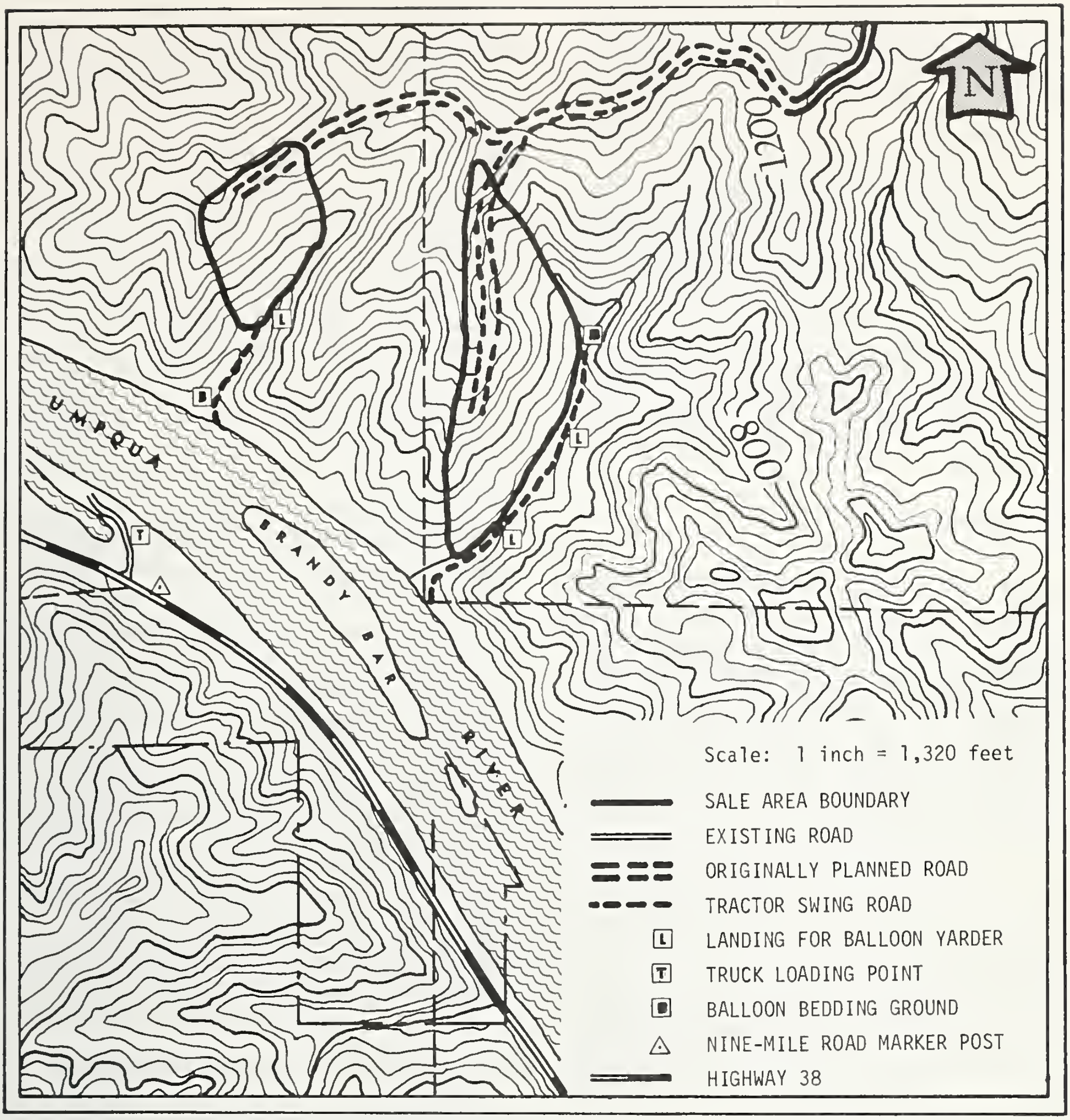

Figure 2.--Timber sale map, Brandy Bar; Smith River Ranger District, Siuslaw National Forest, Secs. 5 and 6, T. 22 S., R. 10 W., Willamette Meridian

yarder was run in third gear, which gave a maximum line speed of 1,700 feet per minute.

Logging Crew

The logging crew consisted of regular employees of Bohemia Lumber Co., some of whom had previous experience on balloon logging operations. The normal crew size was five men--two choker setters, one chaser, one hook tender, and one yarder engineer. They were under the general direction of Frank Mosher, balloon logging superintendent of Bohemia Lumber Co.

Test Procedure

The data were collected by Raven Industries personnel under the test plan prepared by the Pacific Northwest Forest and Range Experiment Station's Forest Engineering Research Project in Seattle. The test plan provided for collecting the following data: equipment performance, effects of weather, daily summary, and cycle time analysis.

TEST RESULTS

Equipment Performance

At the beginning of these tests, the major question was whether the balloon would be sufficiently stable in wind to permit safe log transport.

During operation, the balloon was exposed to winds estimated at 20-25 m.p.h. In these winds, the layover angle was approximately 15° to 20°. The balloon oscillated gently and slowly, having approximately a 35-second period which did not interfere with the logging operation or the control of the balloon.

This test demonstrated that the balloon can be used safely in wind conditions normally expected near the Oregon coast at this time of year. Also, an unusual windstorm on October 2 proved the balloon's ability to survive storm conditions.

Effects of Weather

Adverse weather occurred during August, September, and October. During the test period, extreme forest fire hazard forced closure for 11 full days and 27 half days. This contrasts sharply with the average of only 1.5 full days and 2 half days for this zone during 1956-66.[3] During these closures, the balloon was on the bedding ground.

The windstorm of Monday, October 2, severely tested the wind survival capabilities of the balloon. The storm was described in newspaper reports as the worst in 5 years, and its intensity was exceeded in history only by the Columbus Day storm of 1962. The Weather Bureau officially recorded gusts of 58 m.p.h. at Eugene and 78 m.p.h. at Portland. An unofficial Coast Guard report gave winds of 85 m.p.h. on the coast near Reedsport, approximately 12 miles from the balloon beddown site. Other unofficial reports recounted gusts of 100 to 120 m.p.h. along the coast between North Bend and Newport. The wind caused extensive damage in the entire Oregon coast area.

The balloon was bedded down during the storm in a well-sheltered area to avoid the direct force of the wind. A competent observer estimated the balloon was actually exposed to 50- to 60- m.p.h. winds.

A system of eight tie-down lines (these are visible in the photograph of figure 1) and the main load fitting bedded down the balloon, with approximately one-third of the total lift carried on the load fitting

[3]Oregon State Forestry Department. Annual Close Down Reports. Salem, Oreg. 1956-67.

and the rest on the tie-down lines. With this tie-down arrangement, the balloon successfully resisted the storm, and a careful inspection the next day did not disclose any significant wind damage to the balloon.

Daily Summary

The daily summary (table 1) shows the production and time distribution of the balloon logging system during the test. Total elapsed time from start to finish was 433.7 hours. During this time, the balloon was available for yarding 88 percent of the time. The balloon was not available when maintenance was required during normal working hours (5.4 percent) and when winds were too severe to allow operation (6.6 percent).

Fire weather delays (28.0 percent) and yarder delays (11.4 percent) together represented 39.4 percent of total elapsed test time. Neither of these can be interpreted as representative of normal logging conditions.

Cycle Time Analysis

During the tests, a detailed time breakdown of 105 individual turns was made. The results are shown below:

	Percent of turn time
Haulback	30
Set chokers	19
Inhaul and landing	39
Unhook chokers	12
	100

The following definitions were used in recording these times:

Haulback.--Elapsed time from the instant the chokers leave the landing until the balloon is positioned over the logs and the choker setter grabs the chokers.

Set chokers.--Elapsed time from the instant the choker setter grabs the chokers until the command to lift the log is given.

Inhaul and landing.--Elapsed time from the command to lift the log until the log stops moving in the landing. Includes any time for lifting and resetting the log in the landing if necessary.

Unhook chokers.--Elapsed time from drop of the log to rest on the landing until start of the balloon on the haulback of the next cycle.

Conclusion

This test provided an interesting and productive addition to the developing "state of the art" of balloon logging. With the unusual conditions of fire weather closure, realistic cost figures were not obtainable on these first flight tests of a natural-shaped logging balloon. However, Bohemia Lumber Co. is confident of economical future production.

Indications are that a natural-shaped logging balloon may be considered operational in winds under 25 m.p.h. and capable of surviving storms when properly bedded down in a sheltered location.

Table 1.--Daily summary of balloon logging test, July-October 1967

Date	Total time	Yarding time	Fire closure	Rigging	Balloon handling	Yarder delay	Miscellaneous delay	Wind delay	Balloon maintenance	Balloon availability (total time less wind and balloon maintenance)	Turns	Logs
	-----	-----	-----	-----	-----	*Hours*	-----	-----	-----	-----	*Number*	-----
July 26	4.7	3.9		0.3		0.5				4.7	18	53
27	8.0	6.7			0.2	1.2				8.0	41	114
28	10.0	6.9			2.0		1.1			10.0	56	176
31	8.0	2.2			1.5	.5	3.8			8.0	20	57
Aug. 1	8.0	6.3		.5		.2	1.0			8.0	46	110
2	8.0					8.0				8.0		
3	8.0					8.0				8.0		
4	8.0	4.5	2.1			1.4				8.0	34	78
7	8.5	7.0				.5	.3	0.7		7.8	51	102
8	8.0	5.5	2.4	.1						8.0	46	110
9	8.0	6.9	.8	.2						8.0	56	136
10	8.0	7.0	1.0							8.0	62	173
11	8.0	6.8	1.0	.2						8.0	57	147
14	8.0	1.8			2.2				4.0	4.0	12	37
15	8.0	6.5			1.0		.5			8.0	54	162
16	8.0	2.5				5.5				8.0	26	80
17	8.0					8.0				8.0		
18	8.0					8.0				8.0		
21	8.0		8.0							8.0		
22	8.0		8.0							8.0		
23	8.0		8.0							8.0		
24	8.0		8.0							8.0		
25	8.0		8.0							8.0		
28	8.0					8.0				8.0		
29	8.5	7.0			1.5					8.5	44	136
30	8.0		8.0							8.0		
31	8.0		8.0							8.0		
Sept. 1	8.0		8.0							8.0		
4	8.0		8.0							8.0		
5	8.0		8.0							8.0		
6	8.0		8.0							8.0		
7	8.0		8.0							8.0		
8	8.0		8.0							8.0		
11	8.0	6.0			2.0					8.0	57	157
12	8.0	7.5		.5						8.0	40	90
13	8.0	5.6	2.2	.2						8.0	38	119
14	8.0							8.0				
15	8.0		8.0							8.0		
18	9.0	7.3		.8	.9					9.0	66	215
19	8.5	3.5		.6	1.0		.4		3.4	5.1	23	84
20	8.0								8.0			
21	8.0	7.7					.3			8.0	70	225
22	8.0	6.6		1.1			.3			8.0	53	142
25	8.0	6.5		1.2			.3			8.0	58	174
26	8.0	4.2						3.8		4.2	26	77
27	8.0	2.2					5.8			8.0	20	53
28	8.0	1.5		.3			6.2			8.0	12	31
29	8.5	5.5			3.0					8.5	43	112
Oct. 2	8.0							8.0				
3	8.0							8.0				
4	8.0								8.0			
5	8.0	5.7		1.3	1.0					8.0	43	132
6	8.0	5.1		1.0	1.0		.9			8.0	35	102
9	8.0	6.3		.5	1.2					8.0	56	182
Total	433.7	162.7	121.5	8.8	18.5	49.8	20.9	28.5	23.4	381.8	1,263	3,566
Percentage of total	100	37.5	28.0	2.0	4.3	11.4	4.8	6.6	5.4	88.0		

NOTE:

Average daily performance:

Average turns per hour = 7.8
Average time per turn = 7.73 min.
Logs per turn = 2.82

Board feet per log = 203 gross, 171 net
Board feet per turn = 573 gross, 482 net
Board feet per yarding hour = 4,470 gross, 3,760 net